Integration of HIS Components through Open Standards: An American HIS and a European Image Processing System

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ABSTRACT

This paper describes the integration of an existing American Hospital Information System with a European Image Processing System. Both systems were built independently (with no knowledge of each other), but on open systems standards. The easy integration of these systems demonstrates the major benefit of open standards-based software design.

INTRODUCTION

Diverse medical informatics projects are in progress in many countries, with increasing awareness by the people involved of each others efforts. Some of these projects are centered on systems with open standards-based client/server architecture. A basic tenet of the use of standards in software design is that system integration is facilitated. This paper describes the successful integration of two such systems, validating the premise of this approach to software design.

One of the systems is the hospital information system developed at the Fox Chase Cancer Center, which has a component for acquiring image data from the CT and MRI scanners at Fox Chase. The other system is the Basic Image Processing Service component of the European HELIOS project developed at the German Cancer Research Center. It was proposed in 1992 that the HELIOS image presentation system could be used to present radiographic images acquired by the Fox Chase HIS, and furthermore, that the HELIOS component could be integrated as a component of the Fox Chase HIS. It should be noted that this decision to combine the systems did not occur until both systems were fully formed.

DESCRIPTION OF FOX CHASE CANCER CENTER HIS

The Fox Chase Cancer Center is one of twenty-eight comprehensive cancer centers in the United States. These institutions have been designated as "comprehensive" by the U.S. National Cancer Institute because of their combination of basic research with clinical treatment of cancer patients. Over the past decade a hospital information system has been developed at Fox Chase which supports the medical staff by providing computer access to much of the patient's medical record [1]. Being a cancer center, oncology-specific software has also been developed and incorporated in the hospital information system [2,3]. Recognizing that radiographic images are an essential element of patient data, work was begun in 1989 to present such images along with the text and graphs that comprise the rest of clinical information [4]. The goal of the system design is to present all the information needed by the clinician at the point-of-care. Furthermore, information to support the clinician in their treatment of patients should be presented in a rational and efficient manner [5,6].

The computer systems at Fox Chase Cancer Center have a client-server local area network architecture. A commitment was made in 1989 to use non-proprietary, open standards whenever possible. Commitments were also made to providing a "point-and-click" window-oriented graphical user interface, and to the utilization of the optimum "price-performance" hardware and software. These commitments have resulted in a network of Reduced Instruction Set Computers (RISC) [7] acting as compute and database servers for X-terminal display stations throughout the institution. The X-Windows system [8] is the graphical user interface used.

Physicians, nurses, and administrators all have access to X-terminals, either in their office, at a nurse station, in the clinic, or in their laboratory. These X-terminals can connect to over a dozen RISC servers over the Ethernet. The RISC machines can communicate via the 100 million bits per second Fiber Distributed Data Interface (FDDI) protocol. From an X-terminal various applications can be initiated on one or more of the network RISC platforms. Each RISC machine is dedicated to providing one or more compute services (i.e., applications) or database information.

A distributed client-server network architecture, based on open standards, was also used for acquiring and managing radiographic images [9]. It should be noted that image acquisition is limited to modalities that are inherently digital, specifically CT and MRI. The CT and MRI scanners and the associated film printers are independent network nodes. The scanners transmit image data files upon request from RISC image management workstations. Software on the workstation converts the scanner vendor proprietary header data structure to a format consistent with the ACR-NEMA protocol standard [10]. The technicians have software available on their workstation to perform image manipulations (e.g., window and level settings). Images can be sent from the image management workstations (or any network node or X-terminal) to any film printer on the network. Radiologists can display images while a study is being performed from any X-terminal (such as those in the reading areas).

There are currently nine UNIX RISC processors on the Fox Chase Cancer Center network which serve the medical applications (other nodes are present for serving other applications and users). A minicomputer cluster functions as a database server, and is being phased out as databases are being ported to RISC platforms [11]. There are over100 X-terminals placed throughout the institution at nurse stations, in the Outpatient Clinic, in MRI, CT, and Radiology reading areas, and in offices and laboratories. All software is written in "C." The X-Windows Motif toolkit is used for X-terminal displays. Fiber Distributed Data Interface (FDDI) is used for 100 megabit per second communication between the RISC processors, while 10 megabit Ethernet communication is used to communicate with X-terminals, minicomputers, and scanner computers.

THE EUROPEAN HELIOS PROJECT

HELIOS is one of the projects of the European research program *Advanced Informatics in Medicine AIM* which is funded by the commission of the European Communities. The research program started with a one year exploratory phase in 1990 [13]. The second (3-year) project phase is now running from January 1992 until December 1994.

The goal of the research program AIM is to bring European researchers and industries in different countries together to improve the quality of health care, and to develop new standards in medical informatics.

The consortium of HELIOS was established by seven partners. Prime contractor is the University Hospital Broussais in Paris, France (Prof. Degoulet). Other partners are the University Hospital in Geneva, Switzerland, the University Uppsala, Sweden, the University Linköping, Sweden, and the German Cancer Research Center in Heidelberg, Germany. The industrial partners are CAP Gemini Innovation, Grenoble, France and Digital Equipment BV in Amsterdam, Netherlands.

The goal of HELIOS is to develop a software engineering environment (SEE) for hospital ward information systems (WIS) [14]. The HELIOS SEE will provide tools for the development of main parts of the WIS. The development covers the full life cycle of the system from analysis over design, development and maintenance. The key features of the HELIOS SEE are the object oriented paradigm, a dynamic client/server architecture based on the HELIOS Unification Bus HUB and a graphical user interface [15].

The *kernel* components, which are mandatory for the SEE, are the information system, based on an object oriented database management system, a component for the object oriented analysis, design and development, a user interface manager and a multimedia component [16].

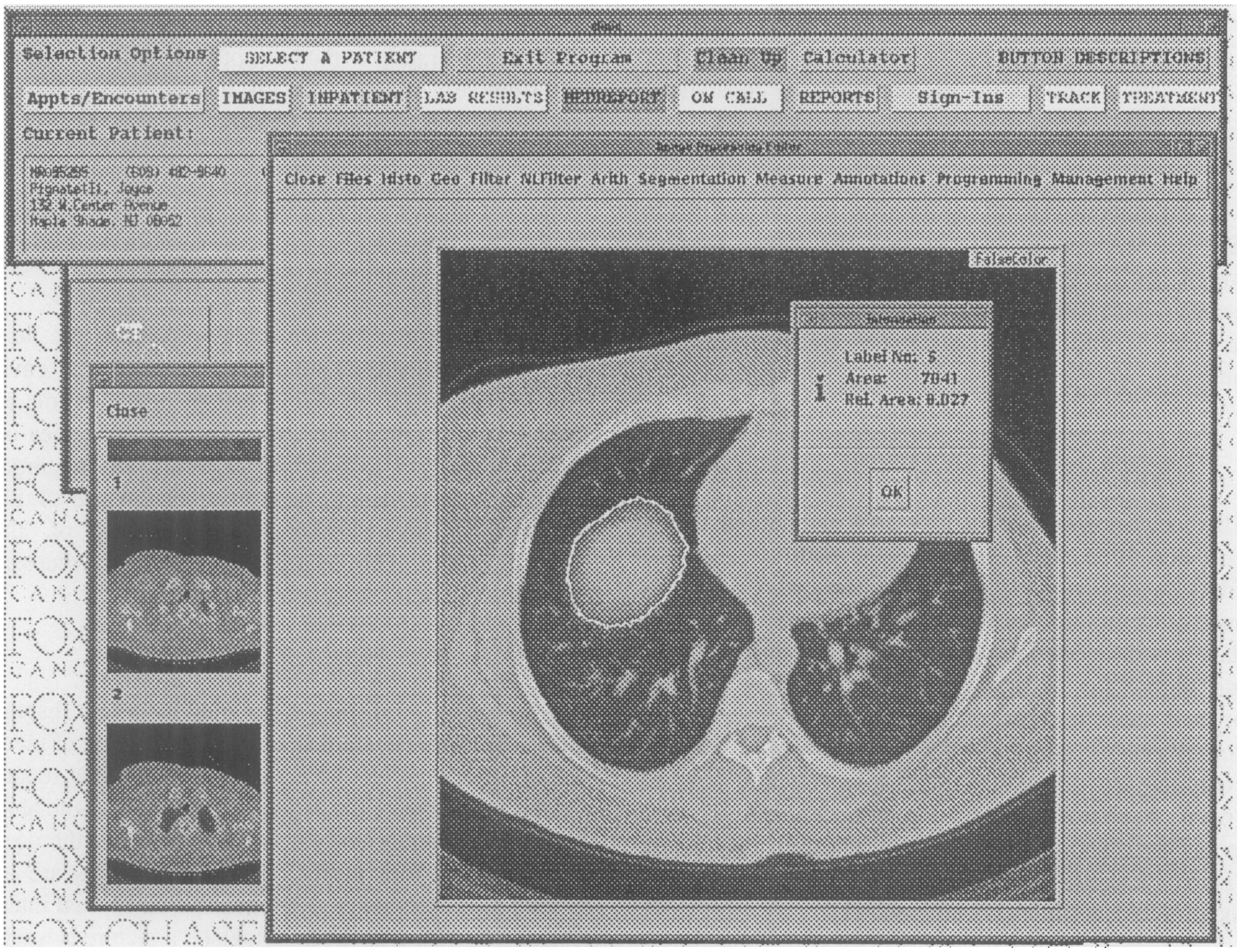
The kernel can be supported by a variable number of *service components*, which can be connected to the *HELIOS Unification Bus HUB* [17]. The HUB integrates all components of a heterogenous hardware and software network and gives the user the feeling of one program running on one single computer. The service components under development are a medical connection service, which connects HELIOS with the HIS and PACS, a medical documentation system, a natural language system, a decision support system and the *Image Related Services (IRS).*

The task of the IRS is to provide all functionality which is related to images. This starts with simple image display and manipulation functions and reaches up to the 3 dimensional recognition of anatomic objects and their visualization with a volume renderer [20]. The first module of the IRS is the *Basic Image Processing Service BIPS.* The development of the BIPS started with the exploratory phase of the project in 1990. The third version of the prototype could be finished in 1992.

Goal of the BIPS

The goal of the BIPS in general is, to provide a software service which can be used in a local area network to display and process images and image sequences. The functions of BIPS can be activated through the graphical user interface or through messages over the HUB [18, 19]. The BIPS is based on several standards, which are the programming language C, the operating system UNIX, the X-Window System, OSF/Motif and the ACR/NEMA image file format. The hardware is usually a RISC workstation integrated in a local area network

Figure 1: The Fox Chase Hospital Information System with the HELIOS Basic Image Processing System



based on TCP/IP on an ethernet or FDDI. Images can be displayed on greyscale, pseudocolor or truecolor displays of the workstation itself or on low cost X-terminals in the local network.

Functions of the BIPS

The functions can be grouped in the following way:

- *Image Display Functions*: The BIPS displays every kind of medical images independent of the modality of the image.
- *File Management*: This function group performs all functions which deal with image storage and retrieval.
- *Image Histogram Manipulations:* The histogram manipulation functions are working on the greyvalues of images.
- *Geometric Transformations*: Change of the image size and orientation plus magnifying glass, regions of interest, etc.
- *Filter Functions*: This group contains a minimal set of digital linear and nonlinear filter functions. Digitally implemented filtering is useful for three major classes of image processing applications: Noise removal, deconvolution, and feature enhancement.
- *Arithmetic Functions*: These functions are performed either on two images or on an image and a constant.
- *Interactive Drawing and Measuring Functions*: These functions are supported by the mouse. The user can measure arbitrary distances between two points, the length of arbitrary shaped curves or the area of drawn regions. A calibration function is available for the calibration of the image sizes to a world coordinate system.
- *Interactive Segmentation Functions*: Interactive segmentation functions can be used to identify relevant structures in the image.
- *Annotations*: These functions can be used to annotate images with text or sound.

- *Programming*: These functions can be used to write macros without typing source code in a text editor. Furthermore, macros can be displayed, edited and executed.
- *Management Functions*: This set of functions allows the customization of the image processing parameters. They can be saved and restored as user profiles.

The functions can be applied on all images in the ACR/NEMA format [11] or in other image formats which can be converted to the internal format. This means independence of the image modality. All modalities can be displayed on the same screen at the same time.

INTEGRATION OF HELIOS BIPS AND FOX CHASE HIS

The integration of the HELIOS BIPS and the Fox Chase HIS benefitted the development of both systems: the BIPS developers had need for implementation experience of their software in a clinical environment, while the Fox Chase developers had need of an image processing toolbox for the radiographic images being acquired by their image management system. Not only were there complementary software development needs, but the common architectural design approach and use of "open" standards made the integration of the two systems very straightforward. As a result, we could "marry" PACS/RIS functionality with the HIS without the problems usually encountered [21].

Common design elements

The HELIOS BIPS and the Fox Chase hospital information system (FC-HIS) are designed to operate in an open local area network client/server environment. Both utilize open standards whenever possible. In particular, both systems use the UNIX operating system, ANSI C programming language, X-Window System graphical user interface with OSF/Motif toolkit, and the ACR/NEMA image data protocol. Very importantly, both HELIOS and Fox Chase are designed for a configuration of X-terminals and RISC machines.

The integration of the of the Basic Image Processing Service (BIPS) with the CT/MRI image services of the Fox Chase system posed a real test of the validity of the open architecture system design. Neither system was constructed with the other in mind. Quite to the contrary, the developers of both systems were ignorant of the others' efforts until both systems were in existence. The image management component of the Fox Chase system was capable of acquiring CT and MRI images from the scanners and storing them in an image file format consistent with the ACR/NEMA protocol. The HELIOS BIPS could present image data stored in this manner on X-terminals. If open systems design was valid, the integration of the two software systems should have been very straight-forward. In fact, the integration was easily accomplished, taking less than two days effort!

Figure 1 shows a screen hardcopy of the integrated system. The upper window is the main interface to the HIS and the other windows are part of the BIPS.

Once BIPS was available to FC-HIS users the next task was to evaluate its suitability in the clinical environment, and make modifications to both systems as needed. For example, the ability to present images on grey-scale as well as color X-terminals was required. Fox Chase users had to be trained in the use of the sophisticated image presentation features of the HELIOS toolkit. This evaluation process continues at this time.

CONCLUSION

The capability to display radiographic image display along with other patient data enhances the value of medical workstations. Just as the electronic medical record makes possession of the paper chart irrelevant, the ability to retrieve images electronically eliminates the need to possess the film jacket. The actual images are an important informational supplement to the textual interpretation provided by the radiologist ("a picture is worth a thousand words"). In addition to basic image display functionality, BIPS provides more specialized tools, such as image measurement and annotation, which could provide for efficient documentation of important clinical information such as tumor size and characteristics. Providing an HIS with image processing tools will lead to both paper- *and* film-less patient management.

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